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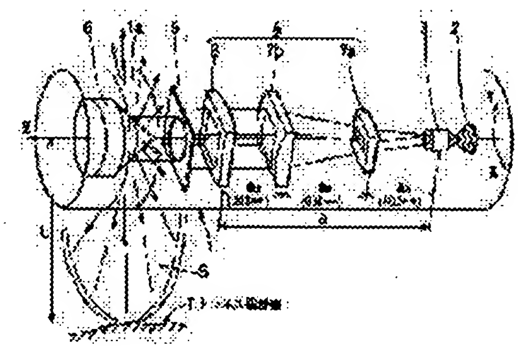
(54) PLANAR-LUMINOUS-FLUX PROJECTING APPARATUS FOR MEASURING OPTICAL CUTTING BEAM

(57)Abstract:
PURPOSE: To obtain a planar-luminous-flux projecting apparatus, which projects radially expanding planar luminous flux toward the surrounding wall surface of an object to be measured such as the surrounding wall surface of a tunnel, and can form the optical cutting beam, which is obtained by narrowing the luminous flux into the narrow width of about several mm and has the high optical power density, on the surrounding wall surface of the object to be measured.



CONSTITUTION: As a light source, a high-output type semiconductor laser 2 is used. Within a YZ plane, the laser beam from the semiconductor laser 2, which is regarded as the point light source, is collimated through a collimate lens 3. Then, the thickness of the beam is expanded through a cylindrical-surface concave lens 7a and a cylindrical-surface convex lens 7b. Converging property is imparted to the thickness-expanded laser beam. The laser beam is

guided to a conical reflecting mirror 6. In an XZ plane, converging property is imparted to the divergent laser beam, which has passed through the collimating lens 3, with a cylindrical surface convex lens 8. The laser beam is guided to the conical reflecting mirror 6. The direction of the laser beam formed in this way is changed with the conical reflecting mirror 6. Thus, the radially expanding planar luminous flux S is projected toward the surrounding wall surface of a tunnel T.

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CLAIMS

[Claim(s)]
[Claim 1] Casing which has the window part for optical passage of the predetermined width of face which allows passage of light the part by the side of nothing and its tip for tubed over the abbreviation perimeter, The optical means which it is arranged [optical means] ahead of the light source arranged in the posterior part in said casing, and said light source in said casing, and makes the flux of light from said light source go to the front, It has the cone-like reflecting mirror projected as the plate-like flux of light which is arranged inside said window part for optical passage, turns the flux of light from said optical means, and spreads in a radial from said window part for optical passage. In the plate-like flux of light floodlighting equipment for optical cutting measurement which projects the plate-like flux of light which spreads in a radial towards the peripheral wall side of the measurement object which should perform a shape measurement with an optical cutting method Said light source is made into the semiconductor laser arranged so that it might see from Z shaft orientations and the laser beam outgoing radiation side whose outgoing radiation optical axis is the direction of an axial center line of said casing, a direction parallel to a pn junction side might see from X shaft orientations and a laser beam outgoing radiation side and a direction perpendicular to a pn junction side might turn into Y shaft orientations. The collimate lens with which said optical means is arranged ahead of said semiconductor laser, and incidence of the laser beam from this semiconductor laser is carried out, It is arranged ahead of this collimate lens, and the thickness of the laser beam made into parallel light with said collimate lens into YZ side is expanded. Plate-like flux of light floodlighting equipment for optical cutting measurement characterized by being constituted by the condenser lens system which gives convergency to the laser beam which has the divergence which passed said collimate lens in XZ side while giving convergency to the laser beam to which this thickness was expanded.
[Claim 2] Plate-like flux of light floodlighting equipment for optical cutting measurement according to claim 1 characterized by having the circular aperture which has circular opening for making into the cross-section circular flux of light the laser beam which passed said condenser lens system between said condenser lens system and said cone-like reflecting mirror in addition to said collimate lens and said condenser lens system.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to amelioration of the plate-like flux of light floodlighting equipment for optical cutting measurement which produces the optical ring-like cutting plane line which projects in detail the plate-like flux of light which spreads in a radial towards measurement object peripheral-wall sides, such as a tunnel peripheral-wall side, about the plate-like flux of light floodlighting equipment for optical cutting measurement used in order to measure a cross-section of tunnel with an optical cutting method, and meets on a measurement object peripheral-wall side in that peripheral-wall side.
[0002]
[Description of the Prior Art] In order to know whether the cross-section configuration of a tunnel has become as the design at the time of tunnel excavation as everyone knows, using an optical cutting method for maintenance check of an established tunnel, and measuring the cross-section configuration of a tunnel is performed. The cross-section configuration of the tunnel in predetermined system of coordinates searches for by measurement of this cross-section of tunnel producing the optical ring-like cutting plane line which projects the plate-like flux of light which spreads in a radial towards the tunnel peripheral wall side perimeter with floodlighting equipment from the inside of a tunnel, and meets on a tunnel peripheral wall side in that hoop direction, picturizing this optical cutting plane line with a television camera, and detecting the location of the optical cutting plane line on the obtained optical cutting image.
[0003] As floodlighting equipment used for such cross-section of tunnel measurement, there is a thing as shown in JP,62-67212,U conventionally. Drawing 6 is the crossing top view of the floodlighting equipment for cross-section of tunnel measurement concerning this conventional technique.
[0004] As shown in drawing 6 , the above-mentioned conventional floodlighting equipment 51 for cross-section of tunnel measurement is constituted as follows. A parabolic reflector 53 is connected to the back end section of the sideways cylinder object 52 in the shape of the same axle, and the outside of the cylinder object 52 and a parabolic reflector 53 is covered by casing 55 through shock absorbing material 54. Moreover, the end plate 57 is being fixed to the front end of the cylinder object 52 and casing 55 through the square shape transparence cylinder 56 which consists of glass etc., and slit-like opening 56a which there is along the field which intersects perpendicularly with the axial center of the cylinder object 52 and a parabolic reflector 53, and allows passage of light over the perimeter by this square shape transparence cylinder 56 is formed.
[0005] The sources 58 of a lamp light, such as a halogen lamp, are arranged in the focal location of the above-mentioned parabolic reflector 53, and inside the above-mentioned cylinder object 52, as shown in drawing, in the front, the 1st convex lens 59 and the 2nd convex lens 60 are arranged in the shape of the same axle in the condition of having made in agreement the focus F by the side of before the 1st convex lens 59, and the focus F on the backside [the 2nd convex lens 60], rather than the source 58 of a lamp light.

[0006] The slit plate 61 which intersects perpendicularly with the axial center of the cylinder object 52 is arranged in the location of the above-mentioned focus F between this 1st convex lens 59 and the 2nd convex lens 60, and the slit hole which carries out opening small in the location of Focus F is opened in the center section of the slit plate 61. Moreover, in order to project as the plate-like flux of light which turns the light which passed the 2nd convex lens 60 at a right angle, and spreads in a radial from slit-like opening 56a, the cone-like reflecting mirror 62 is arranged in the center section of the above-mentioned end plate 57.

[0007] Thus, in the floodlighting equipment 51 for cross-section of tunnel measurement constituted, it is reflected with a parabolic reflector 53 and a part of beam of light emitted from the source 58 of a lamp light turns into a parallel ray, and let it be a parallel ray with the 2nd convex lens 60 after being refracted with the 1st convex lens 59 and converging on Focus F. In addition, a non-converging light which is not converged on Focus F after passing the 1st convex lens 59 will be intercepted with the slit plate 61. And the cone-like reflecting mirror 62 turns the parallel ray which passed the 2nd convex lens 60, and it is projected on it as the plate-like flux of light which spreads in a radial towards the tunnel peripheral wall side T.

[0008] In the above-mentioned floodlighting equipment 51, it is reflected by the parabolic reflector 53 and the optical power emitted into the effective condensing solid angle omega serves as a parallel ray as [show / in drawing 6 / among the optical power emitted into / all / a solid angle from the source 58 of a lamp light]. Moreover, the width of face d of the optical cutting plane line C of the shape of a ring produced along the hoop direction in a tunnel peripheral wall side by projecting the plate-like flux of light which spreads in a radial (thickness of the plate-like flux of light in a tunnel peripheral wall side) It will be decided by magnitude epsilon (magnitude of the source 58 of a lamp light, for example, a filament) of the point emitting light, the optical system which consists of a parabolic reflector 53, convex lenses 59 and 60, and a slit plate 61, and the distance L from the cone-like reflecting mirror 62 to a tunnel peripheral wall side from the geometric relation.

[0009] In the above-mentioned floodlighting equipment 51, magnitude epsilon' of the image of the source 58 of a lamp light in the slit hole location of the slit plate 61 will become epsilon'=epsilon- (f10/A), if the focal distance of f10 and a parabolic reflector 53 is set to A for the focal distance of the 1st convex lens 59. Here, when the aperture phi of the slit plate 61 is designed so that it may become smaller than this epsilon', light emitted from the light source of magnitude phi will be made into a parallel ray with the 2nd convex lens 60, and the optical cutting plane line C of the shape of a ring of width of face d will arise in a tunnel peripheral wall side by the cone-like reflecting mirror's 62 turning this parallel ray, and being projected as the plate-like flux of light.

[0010] If the width of face d of this optical cutting plane line C presupposes that the distance between the 2nd convex lens 60 and the cone-like reflecting mirror 62 is sufficiently short and the focal distance of L and the 2nd convex lens 60 is set to f20 for the distance between the cone-like reflecting mirror 62 and a tunnel peripheral wall side, it will become d=phi - (L/f20). Moreover, the effectiveness eta of the optical power which contributes to formation of the plate-like flux of light on which it is projected among the optical power by the source 58 of a lamp light to a tunnel peripheral wall side is phi/[eta= (omega/4pi) -/ {///[epsilon- (f10/A)] /}] 2. It becomes.

[0011]

[Problem(s) to be Solved by the Invention] In the above-mentioned conventional floodlighting equipment for cross-section of tunnel measurement, sources of a lamp light, such as a halogen lamp, are used as the light source, and since it is made to make a part of light from this source of a lamp light according to a lens system into a parallel ray in order to acquire the plate-like flux of light, an optical cutting plane line with the optical high power density narrowed down on the tunnel peripheral wall side as it is also at narrow width of face about the flux of light is hard to be obtained. for this reason, when picturizing the optical cutting plane line produced on the tunnel peripheral wall side for cross-section of tunnel measurement with a television camera, the optical cutting line image which shows the optical intensity distribution of the shape of a step pulse which changes a lot steeply obtains -- having -- hard -- for example, the optical reflection factor of a tunnel peripheral wall side -- "-- becoming hollow -- " --

etc. -- there was a fault that the measurement precision of a cross-section of tunnel worsened by adhesion in being low.

[0012] This invention is made in order to cancel the above-mentioned conventional fault. In the plate-like flux of light floodlighting equipment for optical cutting measurement which projects the plate-like flux of light which spreads in a radial towards the peripheral wall side of measurement objects, such as a tunnel which should perform a shape measurement with an optical cutting method Measurement object peripheral wall sides, such as a tunnel peripheral wall side, can be made to generate an optical cutting plane line with the optical high power density which narrowed down the flux of light to narrow width of face, and it aims at offer of the plate-like flux of light floodlighting equipment for optical cutting measurement which enabled it to measure a cross-section of tunnel etc. with a sufficient precision by this.

[0013]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the plate-like flux of light floodlighting equipment for optical cutting measurement of claim 1 Casing which has the window part for optical passage of the predetermined width of face which allows passage of light the part by the side of nothing and its tip for tubed over the abbreviation perimeter, The optical means which it is arranged [optical means] ahead of the light source arranged in the posterior part in said casing, and said light source in said casing, and makes the flux of light from said light source go to the front, It has the cone-like reflecting mirror projected as the plate-like flux of light which is arranged inside said window part for optical passage, turns the flux of light from said optical means, and spreads in a radial from said window part for optical passage. In the plate-like flux of light floodlighting equipment for optical cutting measurement which projects the plate-like flux of light which spreads in a radial towards the peripheral wall side of the measurement object which should perform a shape measurement with an optical cutting method Said light source is made into the semiconductor laser arranged so that it might see from Z shaft orientations and the laser beam outgoing radiation side whose outgoing radiation optical axis is the direction of an axial center line of said casing, a direction parallel to a pn junction side might see from X shaft orientations and a laser beam outgoing radiation side and a direction perpendicular to a pn junction side might turn into Y shaft orientations. The collimate lens with which said optical means is arranged ahead of said semiconductor laser, and incidence of the laser beam from this semiconductor laser is carried out, It is arranged ahead of this collimate lens, and the thickness of the laser beam made into parallel light with said collimate lens into YZ side is expanded. While giving convergency to the laser beam to which this thickness was expanded, it is characterized by being constituted by the condenser lens system which gives convergency to the laser beam which has the divergence which passed said collimate lens in XZ side.

[0014] The plate-like flux of light floodlighting equipment for optical cutting measurement of claim 2 is equipped with the circular aperture which has circular opening for making into the cross-section circular flux of light the laser beam which passed said condenser lens system between said condenser lens system and said cone-like reflecting mirror in the plate-like flux of light floodlighting equipment for optical cutting measurement of claim 1.

[0015]

[Function] With the plate-like flux of light floodlighting equipment for optical cutting measurement by this invention, semiconductor laser is used as the light source. When the laser beam by which outgoing radiation is carried out from the point (luminescence field) of the barrier layer in the pn junction of semiconductor laser emitting light makes the direction of an outgoing radiation optical axis Z shaft orientations, it sees from a laser beam outgoing radiation side, and the flare angles (angle of divergence) differ to a pn junction side in an parallel direction (X shaft orientations) and a direction (Y shaft orientations) perpendicular to this. Especially, in the semiconductor laser of a high power mold, as shown in drawing 5 , the directivity of the laser beam by which outgoing radiation is carried out differs in YZ side and XZ side from a large number formation of the point emitting light being carried out along a pn junction side into a barrier layer.

[0016] For this reason, although the parallel ray near an ideal is obtained since magnitude with the point

as the light source emitting light is [/ in YZ side in drawing 5] small when it is going to make into a parallel ray the laser beam by which outgoing radiation was carried out from semiconductor laser with a collimate lens [in XZ side in drawing 5], since magnitude with the point emitting light is large compared with it within YZ side, the parallel ray near an ideal is not obtained but it has divergence.
[0017] Then, since the plate-like flux of light floodlighting equipment for optical cutting measurement by this invention is constituted as mentioned above, it sets in YZ side. After the laser beam from the semiconductor laser it can be considered that is the point light source is made into parallel light with a collimate lens, by the condenser lens system While the laser beam to which the thickness of the beam was expanded can give convergency and is led to a cone-like reflecting mirror, the laser beam which has the divergence which passed the collimate lens in XZ side can give convergency by the condenser lens system, and is led to a cone-like reflecting mirror. Since it was made to project as the plate-like flux of light which turns the laser beam made in this way with a cone-like reflecting mirror, and spreads in a radial towards measurement object peripheral wall sides, such as a tunnel peripheral wall side, measurement object peripheral wall sides, such as a tunnel peripheral wall side, can be made to generate an optical cutting plane line with the optical high power density which narrowed down the flux of light to narrow width of face.
[0018] Moreover, it is desirable to arrange circular aperture between the above-mentioned condenser lens system and a cone-like reflecting mirror. The plate-like flux of light which does not have a local swelling in thickness towards the peripheral wall side of a measurement object can be projected by preparing the laser beam which passed the condenser lens system to the flux of light with that circular cross-section configuration by circular aperture, and projecting the laser beam made into this cross-section circular flux of light on a cone-like reflecting mirror.
[0019]
[Example] Hereafter, this invention is explained based on an example. Drawing for the configuration explanatory view of the plate-like flux of light floodlighting equipment for optical cutting measurement according [drawing 1] to one example of this invention and drawing 2 to explain the actuation within YZ side of the plate-like flux of light floodlighting equipment for optical cutting measurement shown in drawing 1 and drawing 3 are drawings for explaining the actuation within XZ side of the plate-like flux of light floodlighting equipment for optical cutting measurement shown in drawing 1 .
[0020] In drawing 1 , 1 is casing of the cylindrical shape arranged so that the direction of an axial center line may turn into a longitudinal direction of a tunnel. Window part 1a for optical passage of the predetermined width of face which becomes casing 1 from the glass which allows passage of light the part by the side of the tip over the perimeter is prepared. In this casing 1, as shown in drawing, from that posterior part, the high power mold semiconductor laser 2, a collimate lens 3, the condenser lens system 4, the circular aperture 5, and the cone-like reflecting mirror 6 illustrate in order toward the window part 1a side for optical passage, and it twists, attaches, and is arranged in the shape of the same axle by the means.
[0021] The above-mentioned high power mold semiconductor laser 2 has the output power of about 1W, and as shown in drawing, it is arranged so that it may see from Z shaft orientations and the laser beam outgoing radiation side whose outgoing radiation optical axis is the direction of an axial center line of casing 1, a direction parallel to a pn junction side may see from X shaft orientations and a laser beam outgoing radiation side and a direction perpendicular to a pn junction side may turn into Y shaft orientations. In addition, in drawing 1 , the longitudinal direction of a tunnel and Y shaft orientations correspond [Z shaft orientations / the longitudinal direction of a tunnel and X shaft orientations] in the vertical direction of a tunnel, for example.
[0022] The collimate lens 3 with which incidence of the laser beam from the high power mold semiconductor laser 2 is carried out has the focal distance f1. In this example, a collimate lens 3 has an aspheric surface configuration, and are f1= 5.5mm and numerical-aperture NA=0.55.
[0023] The condenser lens system 4 is constituted from 1st yen cylindrical surface concave lens 7a and 2nd yen cylindrical surface convex lens 7b which were arranged with the posture which has a lens operation in Y shaft orientations, and the posture which has a lens operation in X shaft orientations by

the 3rd yen cylindrical surface convex lens 8 arranged in the window part 1a side for optical passage which is the front rather than the above-mentioned 2nd yen cylindrical surface convex lens 7b, as shown in drawing.
[0024] 1st yen cylindrical surface concave lens 7a which has the negative focal distance f2, and 2nd yen cylindrical surface convex lens 7b of a convergence system lens which has the forward focal distance f3 While being for acting as a beam expander in YZ side (Y shaft orientations) and expanding the thickness of the laser beam made into the parallel ray with the collimate lens 3 into YZ side He is trying to give convergency to the laser beam to which this thickness was expanded by 2nd yen cylindrical surface convex lens 7b. 1st yen cylindrical surface concave lens 7a and 2nd yen cylindrical surface convex lens 7b are arranged so that the distance a2 between the principal plane may fill the relation of a2=f2+f3. In this example, it is referred to as f2=-200 mm and f3=1000mm, and is set as a2=800 mm.
[0025] The 3rd yen cylindrical surface convex lens 8 of other convergence system lenses which constitute the condenser lens system 4 is for giving convergency to the laser beam which has the divergence which passed the collimate lens 3 in XZ side (X shaft orientations). If it supposes that distance with the cone-like reflecting mirror 6 is sufficiently short and distance to f4, the cone-like reflecting mirror 6, and the tunnel peripheral wall side T is set to L for a focal distance, the 3rd yen cylindrical surface convex lens 8 is arranged so that the distance a from the principal plane of a collimate lens 3 may fill the relation of 1/f4=(1/a)+ (1/L). In this example, it is referred to as f4=1000mm and L= 4m, and is set as a= 1400mm. In addition, since the above-mentioned 1st yen cylindrical surface concave lens 7a is allotted to the distance a1=400mm location from the principal plane of a collimate lens 3, distance a3 between principal planes of this 3rd yen cylindrical surface convex lens 8 and the above-mentioned 2nd yen cylindrical surface convex lens 7b is set to a3=200 mm.

[0026] The circular aperture 5 is for making into the cross-section circular flux of light the laser beam which passed the 3rd yen cylindrical surface convex lens 8 of the condenser lens system 4 and which is mentioned later, it is arranged between the above-mentioned 3rd yen cylindrical surface convex lens 8 and the cone-like reflecting mirror 6 mentioned later, and circular opening is prepared. The above-mentioned collimate lens 3, the condenser lens system 4, and this circular aperture 5 constitute the optical means.
[0027] The cone-like reflecting mirror 6 is for projecting as the plate-like flux of light S which turns the laser beam which passed the circular aperture 5, and which is mentioned later, and spreads in a radial from window part 1for optical passage a, it is arranged inside window part 1a for optical passage, and the vertical angle is made into 90 degrees.
[0028] Next, it explains, referring to drawing 2 about the actuation within YZ side of the plate-like flux of light floodlighting equipment for optical cutting measurement constituted as mentioned above. For the high power mold semiconductor laser 2 according to this example [in YZ side], the magnitude of the point emitting light is 1 micrometer and outgoing radiation beam flare angle thetaY. It has thetaY =40 degree. Therefore, let the laser beam from the high power mold semiconductor laser 2 be a parallel ray near the ideal which has thickness D1Y with a collimate lens 3. This thickness D1Y is given by D1Y=2, f1, and tan (thetaY / 2), and is set to D1Y=4mm in this example.
[0029] As the laser beam made into the parallel ray which has thickness D1Y with a collimate lens 3 is shown in drawing, the thickness is expanded to D2Y by 1st yen cylindrical surface concave lens 7a and 2nd yen cylindrical surface convex lens 7b. Thickness D2Y is given by D2 Y=M-D1Y, and in this example, since it is M=|f3/f2|, it is set to D2Y=5xD1Y=20mm.
[0030] The laser beam by which this thickness was expanded to D2Y is led to the circular aperture 5 through 2nd yen cylindrical surface convex lens 7b of a convergence system lens, and it will be made the cross-section circular flux of light by the circular aperture 5, and it will be projected on it to the cone-like reflecting mirror 6. Therefore, width of face dY narrowly made in the tunnel peripheral wall side T in Y shaft orientations (the vertical direction of a tunnel) to a diffraction limitation (it is 0.4 mm at L= 4m) The optical cutting plane line C which it has can be made to generate.
[0031] Next, it explains, referring to drawing 3 about the actuation within XZ side of the plate-like flux

of light floodlighting equipment for optical cutting measurement constituted as mentioned above.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the configuration explanatory view of the plate-like flux of light floodlighting equipment for optical cutting measurement by one example of this invention.
[Drawing 2] It is drawing for explaining the actuation within YZ side of the plate-like flux of light floodlighting equipment for optical cutting measurement shown in drawing 1 .
[Drawing 3] It is drawing for explaining the actuation within XZ side of the plate-like flux of light floodlighting equipment for optical cutting measurement shown in drawing 1 .
[Drawing 4] It is the configuration explanatory view of the plate-like flux of light floodlighting equipment for optical cutting measurement by other examples of this invention.
[Drawing 5] It is drawing for explaining high power mold semiconductor laser.
[Drawing 6] It is the crossing top view of the floodlighting equipment for cross-section of tunnel measurement concerning the conventional technique.
[Description of Notations]
1 -- Casing 1a -- Window part for optical passage 2 -- High power mold semiconductor laser 3 -- Collimate lens 4 -- Condenser lens system 5 -- Circular aperture 6 -- Cone-like reflecting mirror 7a -- The 1st yen cylindrical surface concave lens 7b -- The 2nd yen cylindrical surface convex lens 8 -- The 3rd yen cylindrical surface convex lens 11 -- Spherical lens T -- Tunnel peripheral wall side S -- Plate-like flux of light C -- Optical cutting plane line

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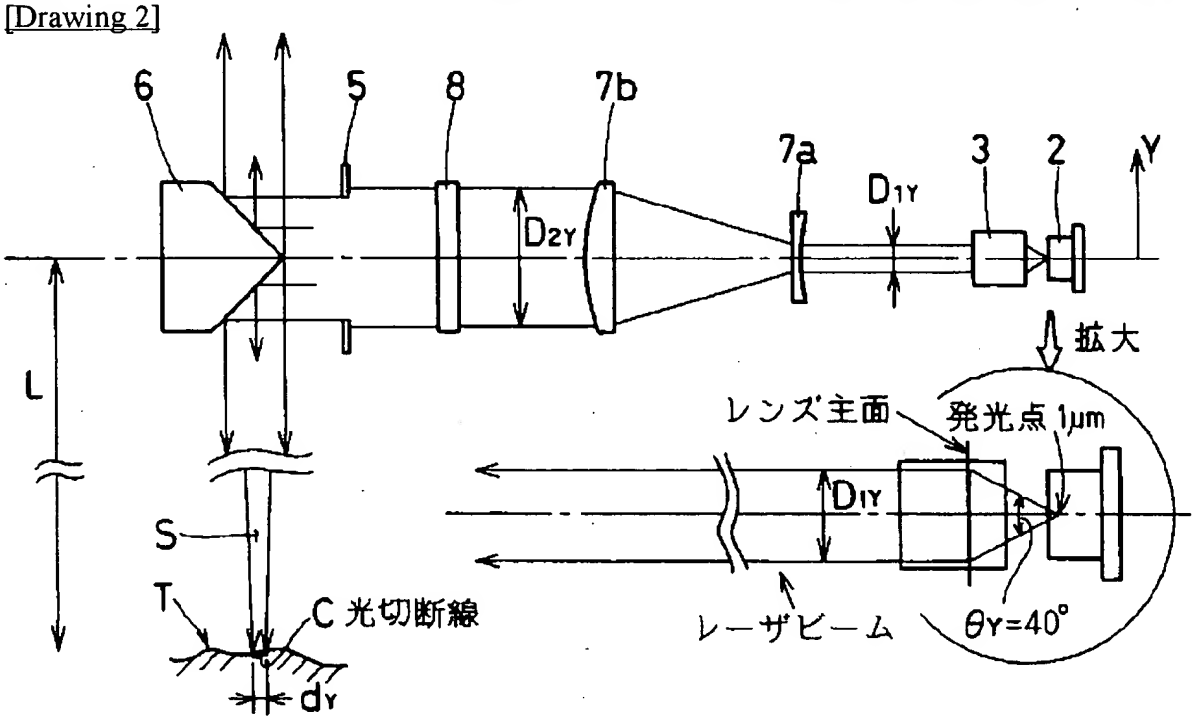
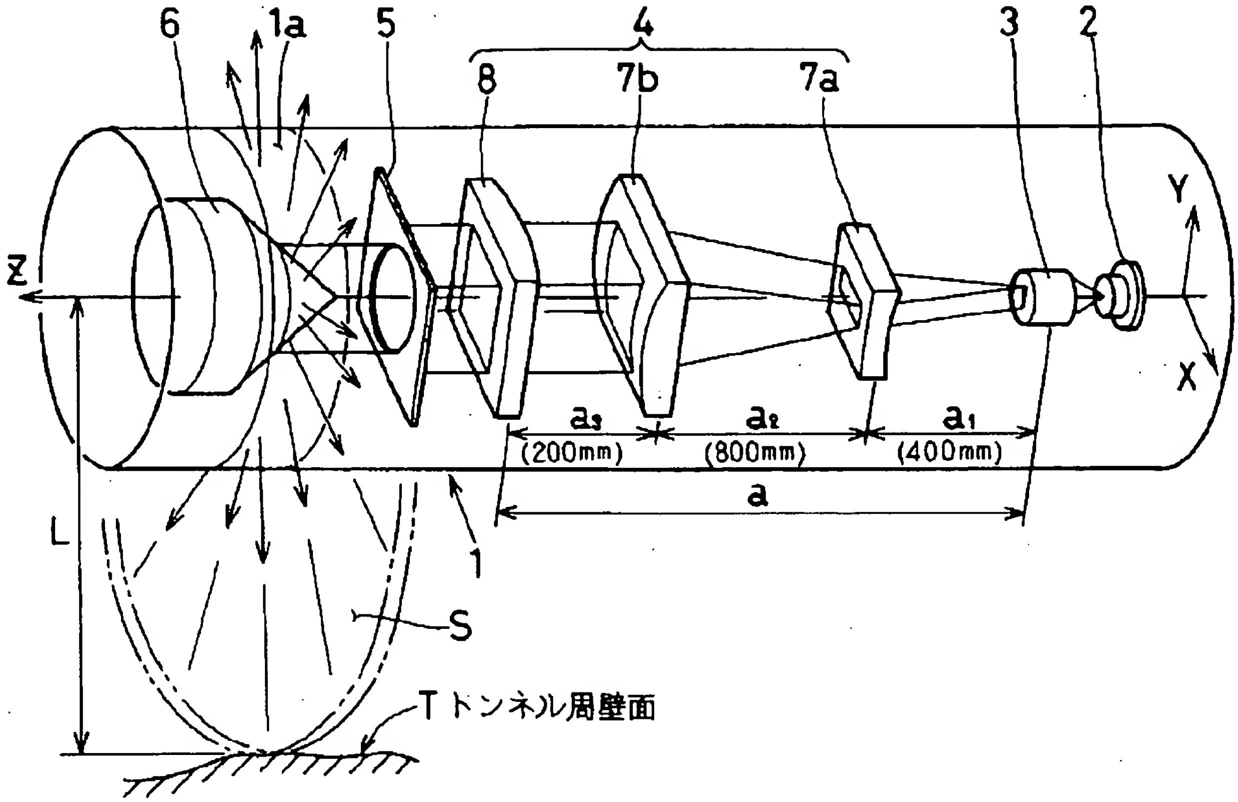
DRAWINGS

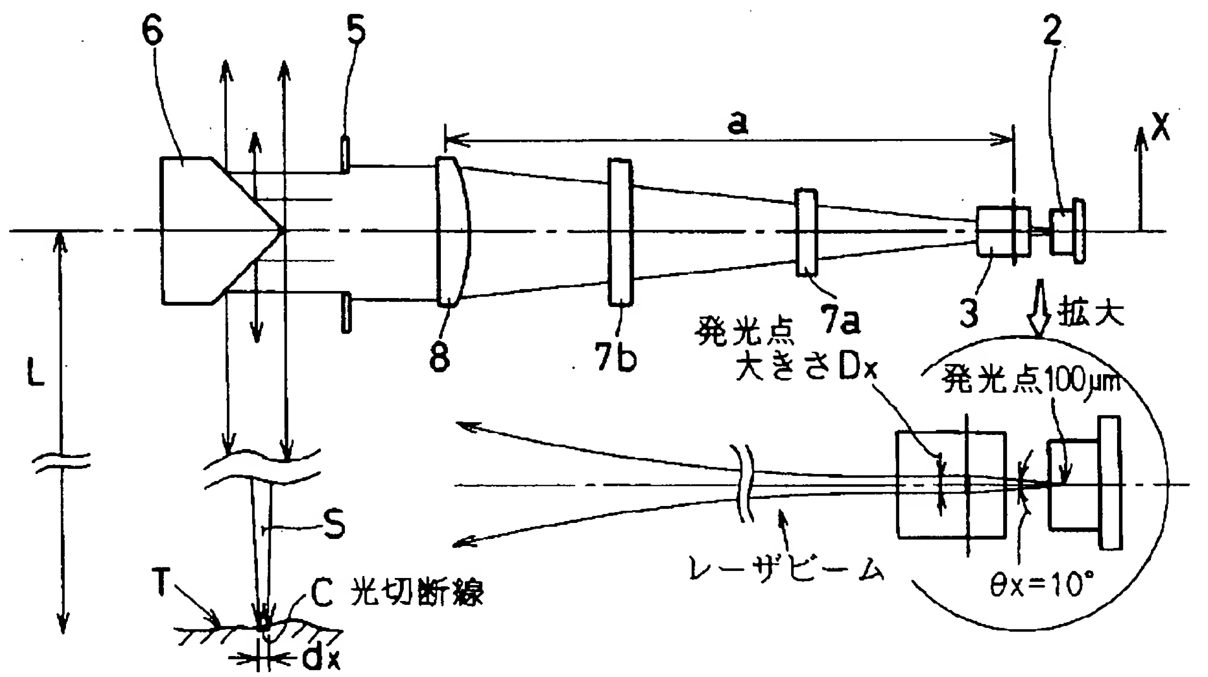
[Drawing 2]



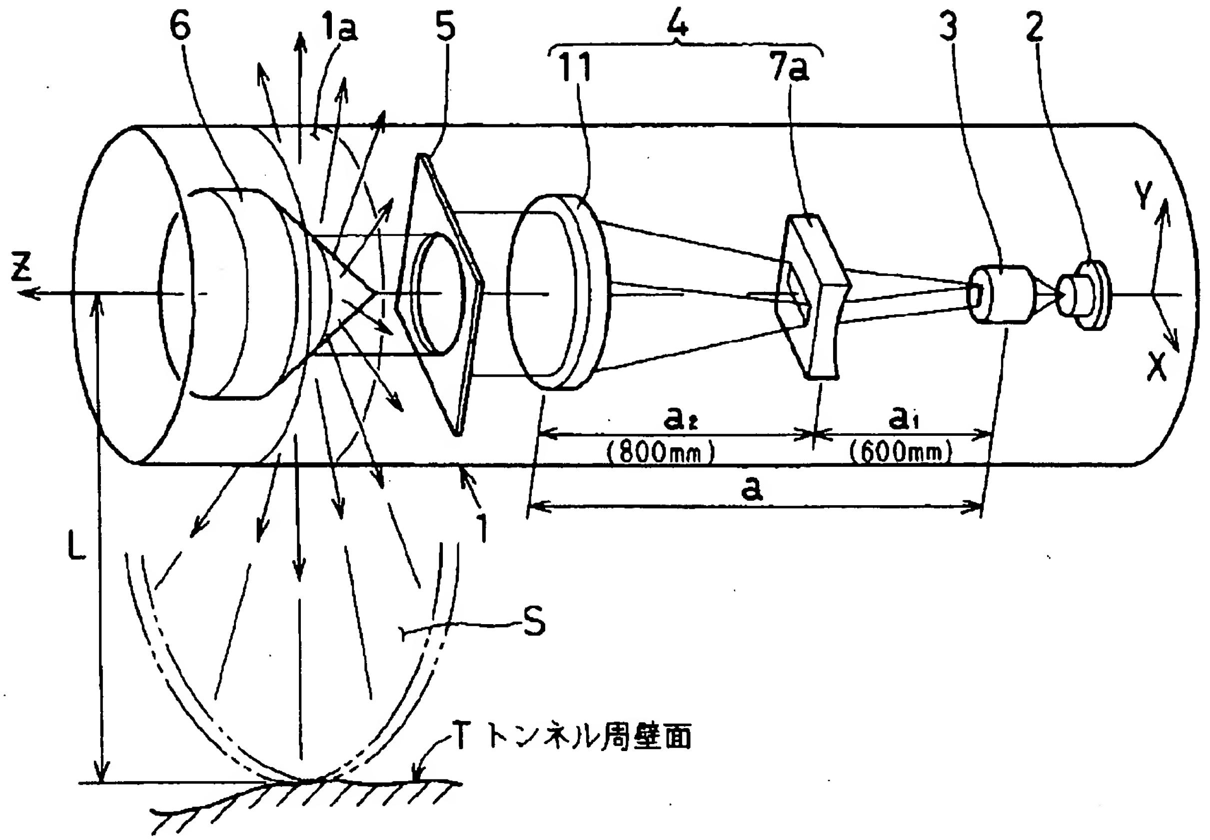
[Drawing 1]



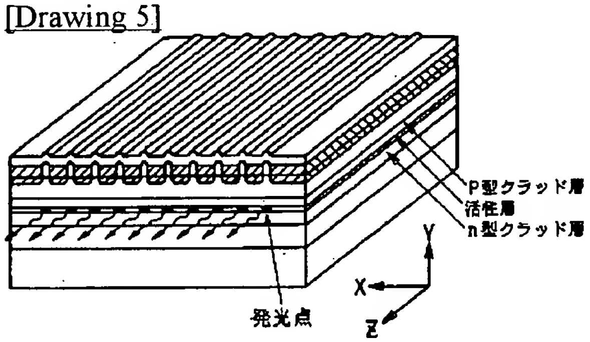
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Drawing 6]